

## CLAIMS

1. An electric field sensor comprising:

a light source (1);

5 an electro optic crystal (7) which is applied with an electric field based on a signal under test, in which a birefringent index changes according to the electric field, and which changes a polarization state of light incident from said light source (1) according to the  
10 birefringent index and emits the light;

a detector (9, 17, 19, 21) that detects an electric signal according to the change of the polarization state of the light emitted from said electro optic crystal (7);

15 a first electrode (11) that is provided close to said electro optic crystal (7), and that applies the electric field based on the signal under test to said electro optic crystal (7);

a second electrode (12) that is provided close to  
20 said electro optic crystal (7), thereby forming a pair with said first electrode (11); and

an auxiliary electrode (61) that is electrically connected to said second electrode (12), and that forms a capacitance with ground.

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2. The electric field sensor according to claim 1, wherein a surface area of said auxiliary electrode (61) is larger than each surface area of said first electrode

(11) and said second electrode (12).

3. The electric field sensor according to claim 2,  
wherein a shape of said auxiliary electrode (61) is any  
5 one of a bar shape, a tabular shape, and a spherical  
shape.

4. The electric field sensor according to claim 1,  
wherein a distance between said auxiliary electrode  
10 (61) and said second electrode (12) is larger than a  
distance between said first electrode (11) and said  
second electrode (12).

5. The electric field sensor according to claim 1,  
15 further comprising distance changing means for changing  
a distance between said auxiliary electrode (61) and  
said second electrode (12) by moving said auxiliary  
electrode (61).

20 6. The electric field sensor according to claim 5,  
further comprising control means (63) for controlling  
said detector (9, 17, 19, 21) to operate when said  
distance changing means separates said auxiliary  
electrode (61) from said second electrode (12) by a  
25 predetermined distance or more.

7. The electric field sensor according to claim 1,  
wherein said auxiliary electrode (61) is insulated from

a circuit that constitutes said detector (9, 17, 19, 21) and a circuit that drives said light source (1).

8. An electric field sensor comprising:

5 a quarter wave plate (5) that converts a P polarized light and an S polarized light into a circularly polarized light, respectively;

10 an electro optic crystal (7) which is applied with an electric field based on a signal under test, in which a birefringent index changes according to the electric field, and which changes a polarization state of the circularly polarized light from said quarter wave plate (5) according to the birefringent index and emits the light;

15 a detector (9, 17, 19) that detects an electric signal according to the change of the polarization state of the light emitted from said electro optic crystal (7); and

20 reflection light separating means (51) that is positioned at a pre-stage of said quarter wave plate (5), that guides an incident P polarized light or S polarized light to said quarter wave plate (5), and guides an S polarized light or a P polarized light obtained by conversion from a circularly polarized light returned from said electro optic crystal (7) by  
25 said quarter wave plate (5), to a direction different from an incident direction of the incident P polarized light or S polarized light.

9. The electric field sensor according to claim 8,  
wherein said reflection light separating means (51) is  
any one of a polarization plate, a polarizing beam  
5 splitter, a Glan-Thompson prism, and a Wollaston prism.

10. The electric field sensor according to claim 9,  
wherein said reflection light separating means (51) is  
a polarizing beam splitter that transmits a P polarized  
10 light and reflects an S polarized light.

11. The electric field sensor according to claim 8,  
further comprising a light source (8) that is positioned  
at a pre-stage of said reflection light separating means  
15 (51) and that emits either one of a P polarized light  
and an S polarized light.

12. An electric field sensor comprising:

an electro optic crystal (7) which is applied with  
20 an electric field based on a signal under test, in which  
a birefringent index changes according to the electric  
field, and which changes a polarization state of  
incident light according to the birefringent index and  
emits the light;

25 a polarizing beam splitter (9) that transmits one  
of a P polarized light component and an S polarized light  
component of the light having the changed polarization  
state which is emitted from said electro optic crystal

(7), and that reflects the other of the polarized light components, thereby splitting said light having the changed polarization state into the P polarized light component and the S polarized light component;

5       a first quarter wave plate (59) that converts the P polarized light component into a circularly polarized light;

10       a second quarter wave plate (57) that converts the S polarized light component into a circularly polarized light;

      a first photo detector (19) that converts the P polarized light component, which is converted into the circularly polarized light by said first quarter wave plate (59), into an electric signal; and

15       a second photo detector (17) that converts the S polarized light component, which is converted into the circularly polarized light by said second quarter wave plate (57), into an electric signal.

20   13. An electric field sensor comprising:

      a light source (1);

25       an electro optic crystal (7) which is applied with an electric field based on a signal under test, in which a birefringent index changes according to the electric field, and which changes a polarization state of light incident from said light source (1) according to the birefringent index and emits the light;

      a pair of electrodes (11, 13) for applying the

electric field based on the signal under test to said electro optic crystal (7);

5 a detector (9, 17, 19, 21) that splits the light emitted from said electro optic crystal (7) into a P polarized light component and an S polarized light component, and obtains an alternate current signal corresponding to a difference between intensities of the respective polarized light components; and

10 compensating means ((6, 8), (27, 31, 29, 23, 25), (27, 31, 29, 33), (43, 44, 45, 47, 49, 29, 23, 25), (43, 44, 45, 47, 49, 29, 33)) for offsetting a change in a polarization state of the light incident from said light source (1) when the electric field is not applied, due to a natural birefringence held by said electro optic crystal (7).

14. The electric field sensor according to claim 13, wherein the light incident to said electro optic crystal (7) is an optional polarized light, and

20 said compensating means comprises:

a quarter wave plate (6) of which an electric main axis coincides with a main axis of an elliptically polarized light emitted from said electro optic crystal (7), and which converts the elliptically polarized light into a linearly polarized light; and

25 a half wave plate (8) that adjusts an angle of a polarization surface of the linearly polarized light emitted from said quarter wave plate (6) based

on a fact that an angle formed between an electric main axis of said half wave plate (8) and the electric main axis of said electro optic crystal (7) is  $n \cdot 45^\circ - \phi_0/2$  (where  $n$  is an integer) when an angle formed between the polarization surface of the linearly polarized light from said quarter wave plate (6) and the electric main axis of said electro optic crystal (7) is  $45^\circ - \phi_0$  without the electric field applied.

15. The electric field sensor according to claim 13, wherein the light incident to said electro optic crystal (7) is a linearly polarized light of which a polarization surface forms an angle  $45^\circ$  with an electric main axis of said electro optic crystal (7), and

said compensating means comprises:

a quarter wave plate (6) of which an electric main axis forms an angle  $45^\circ$  with the electric main axis of said electro optic crystal (7), and which converts an elliptically polarized light emitted from said electro optic crystal (7) into a linearly polarized light; and

a half wave plate (8) that adjusts an angle of a polarization surface of the linearly polarized light emitted from said quarter wave plate (6) based on a fact that an angle formed between an electric main axis of said half wave plate (8) and the electric main axis of said electro optic crystal (7) is  $n \cdot 45^\circ - \phi_0/2$

(where  $n$  is an integer) when a phase difference included in the elliptically polarized light emitted from said electro optic crystal (7) is  $\phi_0$  without the electric field applied.

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16 The electric field sensor according to claim 13, wherein the light incident to said electro optic crystal (7) is a circularly polarized light, and

said compensating means comprises:

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a quarter wave plate (6) of which an electric main axis forms an angle  $45^\circ$  with an electric main axis of said electro optic crystal (7), and which converts an elliptically polarized light emitted from said electro optic crystal (7) into a linearly polarized

15 light; and

a half wave plate (8) that adjusts an angle of a polarization surface of the linearly polarized light emitted from said quarter wave plate (6) based on a fact that an angle formed between an electric main axis of said half wave plate (8) and the electric main axis of said electro optic crystal (7) is  $n \cdot 45^\circ - \phi_0/2$  (where  $n$  is an integer) when a phase difference included in the elliptically polarized light emitted from said electro optic crystal (7) is  $\phi_0$  without the electric field applied.

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17. The electric field sensor according to any one of



claims 14 to 16, wherein  $\phi_0$  is determined based on  
 $\phi_0 = (2\pi/\lambda)(n_o - n_e)L$ , where

$n_o$  is a refractive index of said electro optic  
 crystal for ordinary light,

5  $n_e$  is a refractive index of said electro optic  
 crystal for extraordinary light,

$\lambda$  is a wavelength of light in vacuum, and

$L$  is a length of said electro optic crystal in the  
 direction of light.

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18. The electric field sensor according to claim 13,  
 wherein said compensating means comprises:

15 a pair of control electrodes (23, 25) for applying  
 the electric field based on a control signal (29) to  
 said electro optic crystal; and

control signal generating means ((27, 31), (43,  
 44, 45, 47, 49)) for generating the control signal (29)  
 that offsets a change in the polarization state of the  
 light incident from said light source (1) when the  
 20 electric field based on the signal under test is not  
 applied, based on the alternate current signal obtained  
 by said detector (9, 17, 19, 21).

19. The electric field sensor according to claim 13,  
 25 wherein said compensating means comprises:

an adder (33) that adds a control signal (29) to  
 the signal under test; and

control signal generating means ((27, 31), (43,

44, 45, 47, 49)) for generating the control signal (29) that offsets a change in the polarization state of the light incident from said light source (1) when the electric field based on the signal under test is not applied, based on the alternate current signal obtained by said detector (9, 17, 19, 21).

20. The electric field sensor according to claim 18 or 19, wherein said control signal generating means comprises:

a first buffer amplifier and a second buffer amplifier (43, 44) that input an electric signal based on the P polarized light component and an electric signal based on the S polarized light component, respectively;

a first low-pass filter and a second low-pass filter (45, 47) that input outputs from said first buffer amplifier and said second buffer amplifier (43, 44), respectively; and

an integrator (49) that inputs outputs from said first low-pass filter and said second low-pass filter (45, 47), respectively, and that integrates a difference between the outputs.

21. A method of adjusting an electric field sensor comprising: a light source (1); an electro optic crystal (7) which is applied with an electric field based on a signal under test, in which a birefringent index

changes according to the electric field, and which changes a polarization state of incident optional polarized light according to the birefringent index and emits the light; a pair of electrodes (11, 13) for  
5 applying the electric field based on the signal under test to said electro optic crystal (7); and a detector (9, 17, 19, 21) that splits the light emitted from said electro optic crystal (7) into a P polarized light component and an S polarized light component, and  
10 obtains an alternate current signal corresponding to a difference between intensities of the respective polarized light components, the method comprising:

providing a quarter wave plate (6) that converts an elliptically polarized light emitted from said  
15 electro optic crystal (7) into a linearly polarized light such that an electric main axis of said quarter wave plate (6) coincides with an electric main axis of the elliptically polarized light; and

providing a half wave plate (8) that adjusts an  
20 angle of a polarization surface of the linearly polarized light emitted from said quarter wave plate (6) such that an angle formed between an electric main axis of said half wave plate (8) and the electric main axis of said electro optic crystal (7) becomes  $n \cdot 45^\circ - \phi_0 / 2$   
25 (where  $n$  is an integer) when an angle formed between the polarization surface of the linearly polarized light from said quarter wave plate (6) and the electric main axis of said electro optic crystal (7) is  $45^\circ - \phi_0$

without the electric field applied.

22. A method of adjusting an electric field sensor comprising: a light source (1); an electro optic crystal (7) which is applied with an electric field based on a signal under test, in which a birefringent index changes according to the electric field, and which changes a polarization state of a linearly polarized light whose polarization surface forms an angle  $45^\circ$  with an electric main axis of said electro optic crystal (7) according to the birefringent index and emits the light; a pair of electrodes (11, 13) for applying the electric field based on the signal under test to said electro optic crystal (7); and a detector (9, 17, 19, 21) that splits the light emitted from said electro optic crystal (7) into a P polarized light component and an S polarized light component, and obtains an alternate current signal corresponding to a difference between intensities of the respective polarized light components, the method comprising:

providing a quarter wave plate (6) that converts an elliptically polarized light emitted from said electro optic crystal (7) into a linearly polarized light such that an electric main axis of said quarter wave plate (6) forms an angle  $45^\circ$  with an electric main axis of said electro optic crystal (7); and

providing a half wave plate (8) that adjusts an angle of a polarization surface of the linearly

polarized light emitted from said quarter wave plate (6) such that an angle formed between an electric main axis of said half wave plate (8) and the electric main axis of said electro optic crystal (7) becomes  $n \cdot 45^\circ - \phi_0/2$  (where  $n$  is an integer) when a phase difference included in the elliptically polarized light emitted from said electro optic crystal (7) is  $\phi_0$  without the electric field applied.

23. A method of adjusting an electric field sensor comprising: a light source (1); an electro optic crystal (7) which is applied with an electric field based on a signal under test, in which a birefringent index changes according to the electric field, and which changes a polarization state of incident circularly polarized light according to the birefringent index and emits the light; a pair of electrodes (11, 13) for applying the electric field based on the signal under test to said electro optic crystal (7); and a detector (9, 17, 19, 21) that splits the light emitted from said electro optic crystal (7) into a P polarized light component and an S polarized light component, and obtains an alternate current signal corresponding to a difference between intensities of the respective polarized light components, the method comprising:

providing a quarter wave plate (6) that converts an elliptically polarized light emitted from said electro optic crystal (7) into a linearly polarized

light such that an electric main axis of said quarter wave plate (6) forms an angle  $45^\circ$  with an electric main axis of said electro optic crystal (7); and

5 providing a half wave plate (8) that adjusts an angle of a polarization surface of the linearly polarized light emitted from said quarter wave plate (6) such that an angle formed between an electric main axis of said half wave plate (8) and the electric main axis of said electro optic crystal (7) becomes  $n \cdot 45^\circ - \phi_0/2$   
 10 (where  $n$  is an integer) when a phase difference included in the elliptically polarized light emitted from said electro optic crystal (7) is  $\phi_0$  without the electric field applied.

15 24. The method of adjusting an electric field sensor according to any one of claims 21 to 23, wherein  $\phi_0$  is determined based on  $\phi_0 = (2\pi/\lambda)(n_o - n_e)L$ , where

$n_o$  is a refractive index of said electro optic crystal for ordinary light,

20  $n_e$  is a refractive index of said electro optic crystal for extraordinary light,

$\lambda$  is a wavelength of light in vacuum, and

$L$  is a length of said electro optic crystal in the direction of light.

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25. The method of adjusting an electric field sensor according to any one of claims 21 to 23, wherein  $\phi_0$  is

determined by measurement.

26. A method of adjusting an electric field sensor comprising: a light source (1); an electro optic crystal  
5 (7) which is applied with an electric field based on a signal under test, in which a birefringent index changes according to the electric field, and which changes a polarization state of light incident from said light source (1) according to the birefringent index  
10 and emits the light; a pair of electrodes (11, 13) for applying the electric field based on the signal under test to said electro optic crystal (7); a detector (9, 17, 19, 21) that splits the light emitted from said electro optic crystal (7) into a P polarized light  
15 component and an S polarized light component, and obtains an alternate current signal corresponding to a difference between intensities of the respective polarized light components; a pair of control electrodes (23, 25) for applying an electric field based  
20 on a control signal (29) to said electro optic crystal (7); and control signal generating means (31) for generating the control signal (29), the method comprising:

displaying the alternate current signal obtained  
25 by said detector (9, 17, 19, 21); and

adjusting said control signal generating means (31) to generate the control signal (29) that offsets a change in the polarization state of the light incident

from said light source (1) when the electric field based on the signal under test is not applied, based on the displayed alternate current signal.

5 27. A method of adjusting an electric field sensor comprising: a light source (1); an electro optic crystal (7) which is applied with an electric field based on a signal under test, in which a birefringent index changes according to the electric field, and which  
10 changes a polarization state of light incident from said light source (1) according to the birefringent index and emits the light; a pair of electrodes (11, 13) for applying the electric field based on the signal under test to said electro optic crystal (7); a detector (9,  
15 17, 19, 21) that splits the light emitted from said electro optic crystal (7) into a P polarized light component and an S polarized light component, and obtains an alternate current signal corresponding to a difference between intensities of the respective  
20 polarized light components; an adder (33) that adds a control signal (29) to the signal under test; and control signal generating means (31) for generating said control signal (29), the method comprising:

displaying the alternate current signal obtained  
25 by said detector (9, 17, 19, 21); and

adjusting said control signal generating means (31) to generate the control signal (29) that offsets a change in the polarization state of the light incident



from said light source (1) when the electric field based on the signal under test is not applied, based on the displayed alternate current signal.